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Using Specific or General Software Tools in Power Engineering Education

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Abstract

In present there are a lot of software tools that can be used in Power Engineering laboratories in order to teach a large variety of phenomena. Some of them are dedicated for specific applications like simulation of transient phenomena of electromagnetic and some of them are general purpose tools for modeling and simulating dynamic systems. Technical literature presents a lot of comparison between such tools but the results are presented only from the perspective of research criteria. The scope of this paper is to present how to choose the right tool to be used in a specific laboratory, in order of a better understanding of the phenomena regarding a specific application of power system field. The paper presents a study case of a power system having two high voltage levels, modeled using two different tools: ATP-EMTP – dedicated software and MatLab Simulink – a general analyzing tool. The comparison is done for a power quality study.
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1. Introduction

In the last years, in addition to classical methods of teaching and testing the students' knowledge (Smaill et al., 2012), engineering laboratories have become more and more complex, including simulation tools. In the field of electrical engineering there are many programming environment which can be used both for teaching several phenomena and for research. On line educational tools have an important role in modern education methods. In (Rodríguez et al., 2012) is presented an on-line mathematical tool for electrical circuit assessment and the results of motivating the students to use it. A student feedback is presented and the conclusion is that they agree to use such

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kind of mathematical tool. Due to the cost of hardware laboratories facilities, in the last few years computer assisted educational training is also used on large scale. A multipurpose computer interface unit designed for experiment sets of electrical and electronics laboratories which includes oscilloscope, multimeters, and power sources is presented in (Dursun et al, 2009). In this way, the costs of building a laboratory setup will decrease and a variety of extended experimentation for electrical engineering students can be provided by the interface proposed. One of the most used programming environments is MATLAB/Simulink. This paper presents a comparison for a power system analysis using MatLab Simulink and ATP. The technical education literature presents many papers which treat methods of MatLab Simulink modeling. In (Liao et al., 2012) is presented a modeling technique for practical switched-mode power supplies design course. For the validation of the correctness of the proposed method, four prototype circuits were studied and the conclusion is that the modeling technique can be successfully applied for switched-mode power supplies design. The feedback from students is was also positive. Reference (Francés et al., 2012) uses MatLab GUI like mathematical tool for facilitate the study of interference and optical diffraction phenomena. Another application of MatLab like a mathematical tool for teaching the autocorrelation function and noise concepts is presented in (Jovanovic Dolecek, 2012). In the field of electrical engineering, the most appropriate tool of Matlab Simulink is the SimPowerSystems library. In (Choi & Saeedifard, 2012) is presented a new power electronics laboratory that was developed primarily to reinforce experimentally the fundamental concepts presented in a power electronics course. EMTP/ATP is dedicated software used for power system transient phenomena studies. ATP is used in (Kezunovic & Guo, 2000) for modeling and simulation of the power transformer faults and related protective relay behaviour. The model is verified by using test data and it allows generation of some difficult fault cases for the power transformer protection performance evaluation. A new procedure for tracking the source location of voltage sags in a power system using ATP modeling is presented in (Chang et al., 2007). A validation of voltage sag simulation using ATP is well presented versus field measurements in (Carvalho Filho et al., 2008). In this paper is presented a voltage dip analysis in a network modelled in both MatLab Simulink and ATP. The goal is to familiarize the students with the phenomena of voltage dip propagation in power systems elements at different voltage levels. Technical literature presents a lot of papers which addresses this problem. In (Pedra et al., 2005) is presented the effects of symmetrical and unsymmetrical voltage sags on three-phase three-legged transformers. The propagation of voltage dips in electric power was simulated for medium voltage distribution networks by using an improved ATP circuit-breaker model (Ala et al., 1999). The present paper is organized in 4 sections. The second section presents a short description of the software environments used; section three presents the network configuration for the simulation and the comparative results. Finally, the section 4 presents the conclusions of the papers.

2. Short description of the ATP and MatLab tools

In ATP overhead power lines can be modeled with lumped, distributed and frequency-dependent parameters. Also, the ATP offers the possibility of the user to model an overhead line or a cable, using the LCC module, via specification the geometrical and material data, and the corresponding electrical data are calculated automatically and for Semlyen, J.Marti, Noda line models are generated frequency-dependent line model input data by the supporting routines of APT-EMPT. The model-library of ATP also contains: uncoupled and coupled linear, lumped R, L C elements; nonlinear elements, components with nonlinearities like transformers including saturation and hysteresis; inductive machine; analytical source: DC, step, ramp, sinusoidal, exponential surge functions, electrical components defined by user. It can model in ATP the ideal single phase and three phase transformers, single–phase and 3-phase saturable transformers. As well, and, transformers and autotransformers with two or three windings can be modeled considering the construction of core and technical data given by the manufacturer. In order to simulate Power System in MatLab Simulink, the SimPowerSystem library is used. In this library, overhead power lines can be modeled using PI section line or distributed line parameters. The transformers are modeled depending their type, single or three phases, and taking into account the number of windings. The loads can be modeled by their constant impedances or by constant active and reactive power. Another modeling possibility for consumers is using the dynamic load model (the operating principle is those of the asynchron induction machine). The generators can be modeled using three phase power sources or by implementing own source consisting in three programmable single phase voltage sources.

3. Comparative network modeling in ATP and MatLab

In order to compare the two simulation tolls, an electrical network containing for voltage levels (220 kV, 110 kV, 20 kV and 10 kV) was modelled. The network contains 21 buses: 1 system bus, 4 generator buses, 10 load buses and 6 other buses for interconnection. Electrical loads, respectively load buses, are present at all voltage levels and having different power factors. The loads are represented by impedances corresponding to constant active and reactive powers. For a good representation of a real network, reactive compensation units are operating in each load buses. Overhead power lines are modelled using the PI representation from the software tools libraries.

3.1. Network modeling in ATP

The electric network from Fig.1 was modeled using components contained in the model-library of ATP: the SM59_NC model (synchronous machine, no saturation and control) for synchronous generators; LCC objects for the modeling of electrical overhead lines by 110kV and 220 kV; BCTRAN objects for the modeling of transformers and autotransformers with two winding from substations; Consumers and own technological consumptions of synchronous generators were modeled with RLCY3 objects.
For modeling overhead lines using LCC objects was necessary to know the tower configuration (height of tower, distance from tower to the point of attachment of the conductor, height at midspan), resistance and reactance per unit length (Ω/km) the outer diameter of the conductor. The technical data used for the modeling of transformers and autotransformers are: rated voltages and number of windings.

3.2. Network modeling in MatLab

Fig.2 presents the network structure build in MatLab Simulink. For the power system components, elements from SimPowerSystem Library are used. The generators are modelled using three phase power sources to the corresponding voltage level and the usual parameters. The settings for the generators operating conditions are PV constant. The network simulated is connected to the entire power system by an element called “System” modelled using a three phase power source having corresponding voltage level and the short-circuit power level. For overhead power lines the used model is PI section line and corresponding parameters are measured in per unit length. Therefore the line length is needed. The three phase’s measurement blocks are installed in all the buses of the network and they have been set to measure only the phase to ground voltages.

3.3. Voltage dip simulation and comparative results analysis

Before the voltage dip simulation, the normal operating conditions was established. In generator buses, the voltage control was applied and afterwards for a part of transformers and autotransformers, the ratio of transformation was changed. Due to the fact that the simulation tools don’t have implemented the transformer tap changer, the voltage control was done by changing the nominal voltage of the secondary winding. Voltage dip simulation was realised by using a three phase fault block. Two faults, which can be better seen on the diagram presented in Fig.2, were used to compare the results obtained with the two software tools. In Table 1 are presented comparatively the results obtained for the voltage values on the three phases in all the network load buses. Due to the space limitation in Table 1 are presented the results for only one fault location (at 110 kV level close to the load bus number 10).

Table 1. Voltage values for network load buses

Fault type	Load Number	ATP			MATLAB			Differences		
		A	B	C	A	B	C	A	B	C
Phase-Neutral	1	0.9925	0.9987	0.9933	0.9549	0.9765	1.0000	0.04	0.02	-0.01
	2	0.9772	1.0042	1.0042	0.9541	0.9992	0.9781	0.02	0.00	0.03
	3	0.8411	0.9985	0.9919	0.8392	0.9603	0.9674	0.00	0.04	0.02

	4	0.7249	1.0008	0.9871	0.6050	0.9026	0.9410	0.12	0.10	0.05
	5	0.8681	1.0046	0.9887	0.8114	0.9652	0.9480	0.06	0.04	0.04
	6	0.9179	1.0061	0.9899	0.8825	0.9864	0.9555	0.04	0.02	0.03
	7	0.9781	1.0031	0.9970	0.9503	1.0034	0.9719	0.03	0.00	0.03
	8	0.9280	1.0017	0.9981	0.8960	1.0032	0.9460	0.03	0.00	0.05
	9	0.9204	1.0232	0.9253	0.8086	0.9244	1.0000	0.11	0.10	-0.07
	10	0.5543	1.0036	0.5447	0.5503	0.4516	1.0000	0.00	0.55	-0.46
2 Phases-Neutral	1	0.9918	0.9768	0.9938	0.9610	0.9500	0.9541	0.03	0.03	0.04
	2	0.9980	0.9825	0.9841	0.9559	0.9491	0.9601	0.04	0.03	0.02
	3	0.9623	0.8473	0.8451	0.8654	0.8363	0.8423	0.10	0.01	0.00
	4	0.9583	0.7320	0.7263	0.6850	0.6020	0.6080	0.27	0.13	0.12
	5	0.9756	0.8701	0.8700	0.8317	0.8066	0.8167	0.14	0.06	0.05
	6	0.9819	0.9182	0.9198	0.8875	0.8769	0.8889	0.09	0.04	0.03
	7	0.9924	0.9746	0.9761	0.9509	0.9444	0.9576	0.04	0.03	0.02
	8	0.9734	0.9289	0.9254	0.8983	0.8841	0.9105	0.08	0.04	0.01
	9	0.9348	0.8442	0.9268	0.8451	0.7979	0.8230	0.09	0.05	0.10
	10	0.4840	0.0000	0.4840	0.2064	0.2056	0.0008	0.28	-0.21	0.48
2 Phases	1	0.9824	0.9713	1.0056	1.0008	0.9765	0.9541	-0.02	-0.01	0.05
	2	0.9998	0.9922	0.9913	1.0000	0.9533	0.9781	0.00	0.04	0.01
	3	0.9664	0.8576	0.8717	1.0000	0.8720	0.8888	-0.03	-0.01	-0.02
	4	0.9719	0.8327	0.8485	1.0000	0.7068	0.7367	-0.03	0.13	0.11
	5	0.9533	0.9227	0.9290	1.0000	0.8348	0.8851	-0.05	0.09	0.04
	6	0.9850	0.9531	0.9571	1.0000	0.8865	0.9364	-0.02	0.07	0.02
	7	0.9934	0.9905	0.9890	1.0000	0.9452	0.9814	-0.01	0.05	0.01
	8	1.0056	0.9561	0.9479	1.0000	0.8890	0.9574	0.01	0.07	-0.01
	9	1.0042	0.8360	1.0018	1.0163	0.8976	0.8229	-0.01	-0.06	0.18
	10	0.8800	0.0000	0.8800	0.8660	0.8662	0.0002	0.01	-0.87	0.88
3 Phases	1	0.9816	0.9818	0.9826	0.9541	0.9541	0.9541	0.03	0.03	0.03
	2	0.9831	0.9817	0.9834	0.9541	0.9541	0.9541	0.03	0.03	0.03
	3	0.8427	0.8440	0.8402	0.8368	0.8368	0.8368	0.01	0.01	0.00
	4	0.7317	0.7335	0.7313	0.6014	0.6014	0.6015	0.13	0.13	0.13
	5	0.8689	0.8694	0.8684	0.8085	0.8085	0.8085	0.06	0.06	0.06
	6	0.9166	0.9168	0.9162	0.8804	0.8804	0.8804	0.04	0.04	0.04
	7	0.9721	0.9724	0.9718	0.9510	0.9510	0.9510	0.02	0.02	0.02
	8	0.9145	0.9216	0.9160	0.8970	0.8971	0.8971	0.02	0.02	0.02
	9	0.8612	0.8628	0.8517	0.8229	0.8229	0.8230	0.04	0.04	0.03
	10	0.0000	0.0000	0.0000	0.0006	0.0003	0.0004	0.00	0.00	0.00

As it can be observed from Table 1, the differences obtained using the two simulation tools are small. Both tools can be confidently used for voltage dip propagation studies, but ATP presents a little advantage regarding the transformers modeling. In ATP the group connection transformer can be chose and the differences obtained for our application are highlighted in Table 1 using bold font. Using MatLab simulation the fault phase (phases) is the same at all voltage levels, but in ATP simulation, the fault phase (phases) is changing according to the group connection transformer.

4. Conclusions

An important element in electrical engineering education, for better understanding the phenomena of reality, is simulation software tool. In the paper is presented a network simulated using ATP and MatLab. The goal of the simulation is to prove the voltage dip propagation in case of a single or multiphase fault. The results are presented comparatively and it can be seen that ATP has an advantage in modeling of transformers which conduce to a better representation of the reality. From the point of view of general network representation, the user can remark some differences between the two tools. First of all, ATP use the single line diagram of the network and MatLab Simulink use a three phase diagram. The representation in ATP is more intuitive for the students regarding the operating of the network, but in three phases representation, used in MatLab, the students have a more accurate imagine of how is happen the things in reality. Regarding the way of setting the elements parameters, ATP is more flexible because it allow to introduce the parameters in different ways including for some elements event the catalogue data; MatLab is more restrictive and the students must to compute the parameters in accordance with MatLab specifications. Regarding the way of providing the results, MatLab has an advantage due to the “PowerGuy” function. In MatLab the results can be obtained centralized in root mean square values.Finally, even if the ATP have some advantage over MatLab, taking into account that the students of our department are habituated to use MatLab from the experience of other laboratories, is recommended to be used also for voltage dip analysis.

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